# Beyond Integration Readiness Level (IRL): A Multi-Dimensional Framework to Facilitate the Integation of System of Systems

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***Abstract*—Integration Readiness Level (IRL) can be an effective systems engineering tool to facilitate integration of systems. With further research and the use of systems architecture methodology, IRL principles could enhance the use of systems integration in Department of Defense (DoD) Acquisitions. DoD space systems are great examples of system of systems, and analyzing space systems' integration issues will help identify critical integration variables. Integration data will be collected to develop a framework to enhance IRL notional definitions that will help improve space systems' availability and dependability.**

***Keywords-Integration Readiness Level (IRL); Department of Defense (DoD) Acquisitions; Technology Readiness Level (TRL).***

## I. INTRODUCTION

Integration Readiness Level (IRL) was introduced to help understand the maturity of integrating one system to another [1]. The need to expand the use of IRL is increasingly becoming more relevant in the United States' Department of Defense (DoD) Acquisitions as programs try to acquire systems with the intent to have multiple capabilities and interfaces.

Throughout the years, DoD has continuously reduced the budget for weapon systems acquisitions. DoD Acquisitions implemented several systems engineering processes and tools to help meet budgetary requirements and still produce the best weapon systems available. The budget reduction along with the need to expedite the deployment of capabilities into operations trigger the drive to improve these processes and tools that program managers can depend on when making program decisions. In order to make decisions about a system and the technology available for the system, DoD Acquisitions adopted the use of Technology Readiness Level (TRL) in 2002 [2]. TRL provides close to a quantitative measure for explaining the maturity of a system based on the technology used for that system.

To further the use of TRL, IRL was introduced as an integration tool to complement TRL (Figure 1). IRL was developed to align with the TRL definitions, but it was never officially implemented by DoD to help with integration assessment. Other readiness levels such as System Readiness Level (SRL) and Test Readiness Level were also introduced but not officially recognized by DoD Acquisitions. Although not implemented, the use of IRL could become a necessary tool to help reduce integration risks of complex systems. Integrating system of systems are becoming more complex and the current definitions of IRL do not allow it to be independent of the TRL process, which could be one reason why IRL is heavily scrutinized in current systems engineering literature.

| Lvl | TRL | IRL |
|---|---|---|
| 1 | Basic principles observed and reported | An interface between technologies has been identified with sufficient detail to allow characterization of the relationship |
| 2 | Technology concept and/or application formulated | There is some level of specificity to characterize the interaction between technologies through their interface |
| 3 | Analytical and experimental critical function and/or characteristic proof of concept | There is compatibility between technologies to orderly and efficiently integrate and interact |
| 4 | Component and/or breadboard validation in laboratory environment | There is sufficient detail in the quality and assurance of the integration between technologies |
| 5 | Component and/or breadboard validation in relevant environment | There is sufficient control between technologies necessary to establish, manage, and terminate the integration |
| 6 | System/subsystem model demonstration in relevant environment | The integrating technologies can accept, translate, and structure information for its intended application |
| 7 | System prototype demonstration in relevant environment | The integration of technologies has been verified and validated with sufficient detail to be actionable |
| 8 | Actual system completed and qualified through test and demonstration | Actual integration completed and mission qualified through test and demonstration in the system environment |
| 9 | Integration is mission proven through successful mission operations | Execute a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle |

Figure 1. IRL and TRL Levels Defined [1]

## II. THEORY

IRL can be an effective systems integration assessment tool and given the right multi-dimensional framework, it can facilitate the integration of system of systems. Utilizing other integration variables and expanding the current notional definitions of IRL can significantly impact the assessment of integration of system of systems. IRL was also proposed as an intermediate step by making it part of a matrix function with TRL in order to determine the SRL [2].

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When IRL is used as a function of SRL, IRL could be overlooked from being a significant independent assessment value, and the IRL level may be influenced by what is needed as the SRL value. There are others who determine integration readiness can be assessed as part of DoD Acquisition's Technology Readiness Assessment (TRA) process, which is the official process to determine TRL score, but this process does not capture the purpose of integration. It is important to understand that a system with mature technology does not automatically equate to having a high IRL when interfacing with another system with mature technology. The current high-level definition given to IRL levels from 1 to 9 allows room for different interpretations when working with complex systems.

DoD space systems continue to provide examples of complex system of systems. With very limited opportunities to do operational tests and analyses for satellite systems and rocket launches, space systems provide a platform to incorporate the latest technologies and processes to attain successful operational systems. IRL can be used to assess the integration of these systems given a rigorous process that account for other variables. An assessment based on the current definition, which allows subjectivity that may be misinterpreted, will not work with current space systems.

A research is being performed to show the effectiveness of IRL in facilitating integration of system of systems. The research will focus on understanding the integration points with additional critical variables, and focus on the development of a systems architecture that will provide the framework to explain enhanced IRL levels. A systems architecture will be used as the methodology to prove the effectiveness of a newly defined IRL process.

## III. GOALS/RESULTS

The goal is to expand beyond the IRL notional identified levels using architectural framework and assessed integration variables. To determine the integration variables, the research will focus on understanding the integration issues of six major DoD space systems. The data will be collected from the following family of systems: 1) Advanced Extremely High Frequency (AEHF) satellite; 2) Evolved Expendable Launch Vehicle (EELV); 3) Global Positioning Satellite (GPS); 4) National Polar-Orbiting Observing Satellite System (NPOESS); 5) Space Based Infrared Systems (SBIRS); and 6) Wideband Global SATCOM (WGS). The research will focus on integration issues from 1999 to 2014, and the data will be analyzed to understand the overall impact on capability, schedule, and cost. The focus of the integration issues will be at the space segment integration points (Figure 2) along with the subsystems integrated into each of the space segment.

The data collected will be used to construct an architectural framework and to determine weights for each identified variable. The framework and weighted variables will determine an objective IRL level. Initial integration variables that are being considered include: 1) Schedule (need date, allowed timeline to integrate); 2) Resources (Funding, Personnel, Available tools); 3) Processes (Documented approach, Binding Agreements, Testing); 4) Policies (Directives, Guidance); 5) Communication (Documentation, Semantics, Expectations); and 6) Risks (Cost, Schedule, Technical).

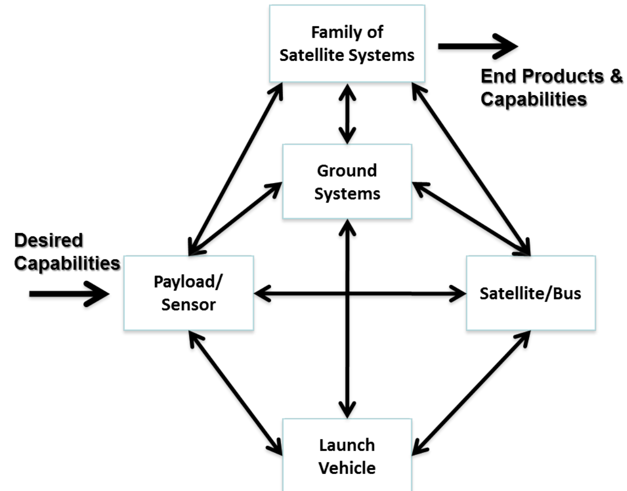


Figure 2. Major DoD Space Systems Integration Points

## IV. CONCLUSION

The data will be validated through systems architecture application of the integration activities for all six space systems. The data collected will also be manipulated through regression analyses to determine possible trends that can support or object to the theory being researched. The systems architecture methodology will help scope the data collected and help facilitate the use of critical integration variables into relevant products that can be used to support overall program decisions and improve system availability and dependability.

The expected result is to have a list of integration issues and an understanding of how those issues impacted the system delivery through time, level of capability, and schedule. This will help identify attributes that will be used as variables for systems integration. Although the current DoD process of deploying space system capabilities for operational use does not require assessment of integration maturity, the result of this research should help quantify an integration tool that can further the use of IRL principles. Thus, making it very useful for stakeholders' decisions. With further research, using IRL with additional variables applied into a multidimensional architectural framework will provide a systems engineering quantitative tool that can enhance the facilitation of integrating system of systems.

## V. REFERENCES

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